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FOREST INSECT INVESTIGATIONS

REPORT

OF

RELATION OF EPIDEMICS ON THE BLACK HILLS BEETLE TO PRECEDING TREE GROWTH.

By
M.W. Blackman,
Specialist in Scolytidae
U.S. Bureau of Entomology.
November 5, 1926

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GOVERNMENT PRINTING OFFICE

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During late August and early September an attempt was made to collect data which would show whether or not there existed any relation between the incidence of an epidemic and radial growth during the preceeding years. In the beginning of this work the stumps of trees treated in control work were studied and measurements were made of the radial growth of the two 5-year periods preceeding the death of each tree. Also a number of cores were taken from standing green trees unaffected by the epidemic. On these latter measurements were made not only of the growth during the same years measured on the stumps of treated trees, but also of the growth during the period since the treatment. Thus a basis of comparison was secured of growth preceeding the epidemic, during the epidemic and following it. Part of these data were collected in the region including Three-Lakes and Mile-and-a-Half and the rest at Bright Angel Point on the North Rim of the Grand Canyon.

At Bright Angel Point measurements were made on the stumps of 138 trees killed in 1921 and treated in 1922, and increment cores were taken from 57 green trees, unaffected in any way by the epidemic. The following is a summary of the data taken at Bright Angel Point.

Trees Treated in 1922.

Radial Growth of 138 dead trees B.A. PT -	1912-1916	1072.25 MM
" " " " " " " " -	1917-1921	1045.20
Av. Rad. gr. per tree of 138 dead trees B.A.PT.	1912-1916	7.777
" " " " " " " " "	1917-1921	7.574
Av. Rad.gr. per yr.pertree 138 dead trees" "	1912-1916	1.355
" " " " " " " " " "	1917-1921	1.313

Green Trees

Radial Growth in 57 Green trees B.A. PT.	1912-1916	510.3
" " " " " " "	1917-1921	456.7
" " " " " " "	1922-1926	423.2
Av. Rad. Gr. per tree 57" " " " "	1912-1916	8.95
" " " " " " " " " "	1917-1921	8.01
" " " " " " " " " "	1922-1926	7.42
Av. Rad. Gr. per yr. per tree 57 green trees B.A. PT.	1912-1916 . . .	1.79
" " " " " " " " " " " "	1917-1921 . . .	1.60
" " " " " " " " " " " "	1922-1926 . . .	1.48

In the Mile-and-aHalf, Three Lakes region measurements were taken from 58 dead trees and 57 green trees. The green trees were chosen as showing especially rapid growth uninfluenced by any recent change in competition due to insect epidemics or any other discoverable cause.

MILE-AND-A-HALF AND THREE LAKES - DEAD TREES

Radial Growth in 58 dead Trees 1912-1916	329.9
" " " " " " 1917-1921	278.6
Av. Rad. Gr. per tree in 58 dead trees 1912-1916	5.687
" " " " " " " " 1917-1921	4.80
Av. Rad. Gr. per yr. per tree in 58 dead trees 1912-1916	1.137
" " " " " " " " " " 1917-1921	.96

Green Trees

Radial Growth in 57 green trees 1912-1916	488.2
" " " " " " 1917-1921	443.1
" " " " " " 1922-1926	394.1
Av. Rad. Gr. per tree in 57 greent trees 1912-1916	9.04
" " " " " " " " 1917-1921	8.2
" " " " " " " " 1922-1926	7.3
Av. Rad. gr. per yr. per tree in 57 green trees 1912-1916	1.81
" " " " " " " " " " 1917-1921	1.64
" " " " " " " " " " 1922-1926	1.46

The data obtained in this study are consistent throughout and that on both the trees killed by the epidemic and on the surviving green trees in no way affected by the epidemic show a decrease in the rate of growth as taken for 5-year periods from 1912 to the time of treatment. Furthermore, the green trees show a continued decreasing rate of growth for the 5-year period from 1922 to 1926.

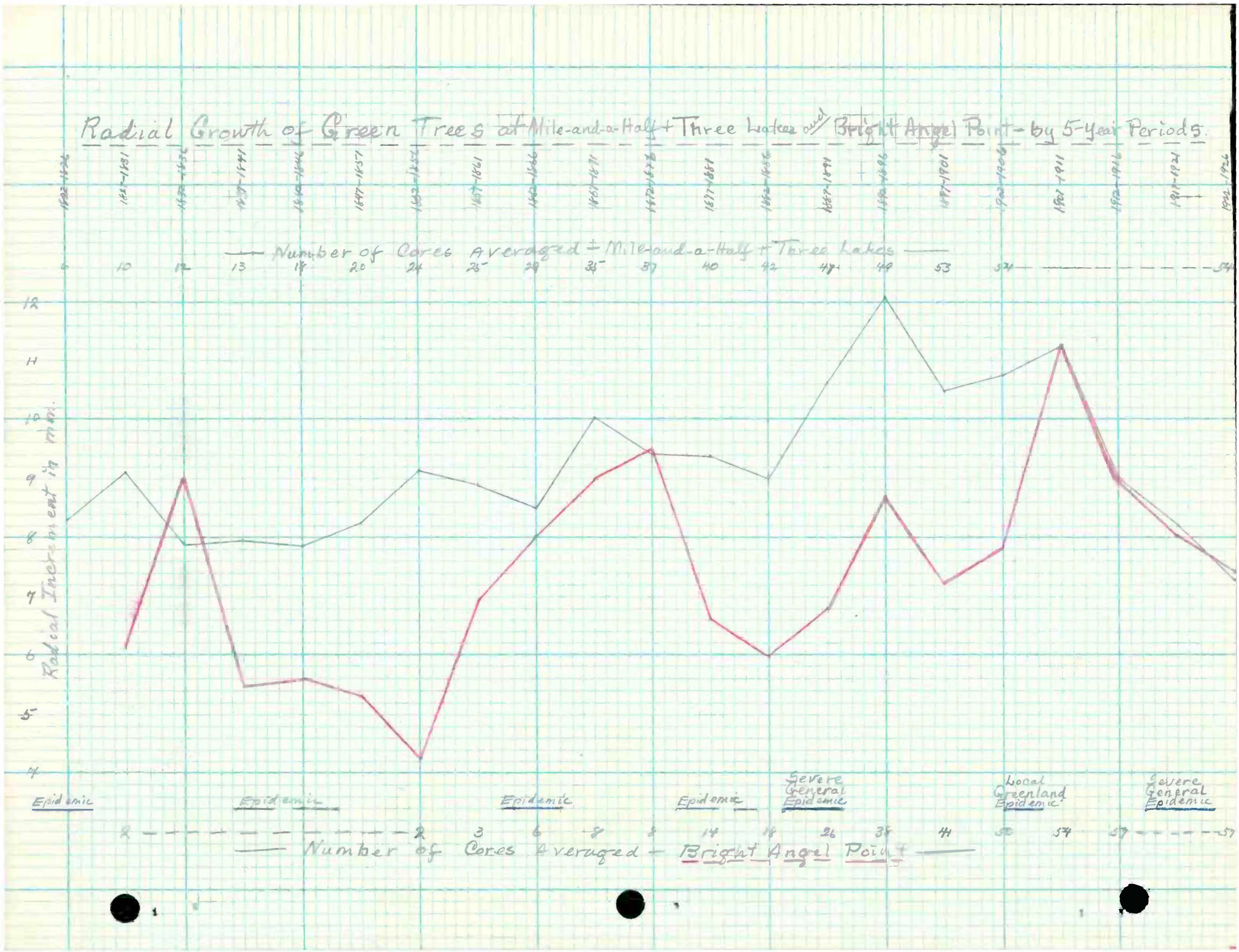
As the epidemic assumed alarming proportions in 1919 and 1920 it must have been developing in various parts of the forest for several years preceeding that - the infestation probably taking on the form of group killings about 1915 - 1917 and the size of the group increasing until the time it began to attract general attention. This means that for a period of at least six years before the epidemic began to develope the growth as measured by 5-year periods was on the decline both in the trees later killed and in those surviving.

This lead seemed so interesting that it caused me to measure by 5-year periods the entire cores taken at Bright Angel and 35 miles farther north. When these measurements were compiled it gave rise to the data from which the accompanying graphs were constructed. These graphs show similar general tendencies but also individual differences which would be expected in areas 35 miles apart and differing so greatly in the character of the adjacent topography.

The graph representing growth in the Mile-and-a-Half - Three Lakes area should be more reliable than that of Bright Angel Point, because the trees in the former area were chosen with much greater care. An attempt was made here to eliminate in so far as possible all other governing factors except that of soil moisture available to the trees. The trees used occurred either in the open or in very open stands and were chosen only after a careful examination as being free of any old or recent mechanical injury - such as those due to lightening, wind break or fire - and as having experienced no discoverable change in competition within a period of 50 years or more. The trees at Bright Angel were not selected so carefully. This is responsible for the very evident fact that the

growth is considerably more rapid at Mile-and-a-Half and that the curve is more even. In other words, the curve of growth at Mile-and-a-Half - Three Lakes represents the available moisture as closely as it appears possible to obtain it in the absence of actual precipitation records.

Radial Growth of Green Trees at Mile-and-a-Half + Three Lakes and Bright Angel Point - by 5-year Periods.



RELATION OF EPIDEMICS TO PRECEEDING ANNUAL GROWTH

It soon became very evident, however, that measurements of growth by 5-year periods could show only general tendencies, so as soon as a core measuring apparatus was available a number of cores from each area were measured for yearly growth. In making this more detailed study of annual growth twenty-five cores were selected from each area. Those chosen were the average in each area as determined by the measurements by 5-year periods and which at no place showed any sudden great increase or decrease of growth, not characteristic of the average core for the area. In other words an attempt was made to eliminate still further all factors except that of available moisture.

This data is incorporated in the accompanying graphs representing average yearly growth in the two regions. In this graph the approximate dates of past epidemics are also shown. These dates were arrived at by a study of increment cores taken adjacent to dead trees still on the ground and as has been intimated are to be considered as approximate dates only. Trees vary so much as to the promptness with which they respond to release from competition that in the case of old killings it is possible only to date the killing within two or three years. Of these old killings the most intense and general one is that centering around 1890. Conclusive evidence of wide spread destruction is to be seen in various parts of the forest such as Dry Park, Mile-and-a-Half, Three Lakes, Murray Lake, etc. At these places the devastation was nearly as great as in the epidemic just ended. There is considerable evidence for the opinion that this wide spread epidemic is really a continuation of one starting in the late 1870's and continuing with varying intensity till the early 1890's. Further mention will be made of this later. The epidemic centering in 1908 was apparently more or less localized on the Greenland Plateau and evidence is lacking of killings elsewhere at this time at all comparable to that on Greenland. The other epidemics are more or less problematical and while there is considerable evidence of each one indicated on the graph this is not so conclusive as in the more recent killings.

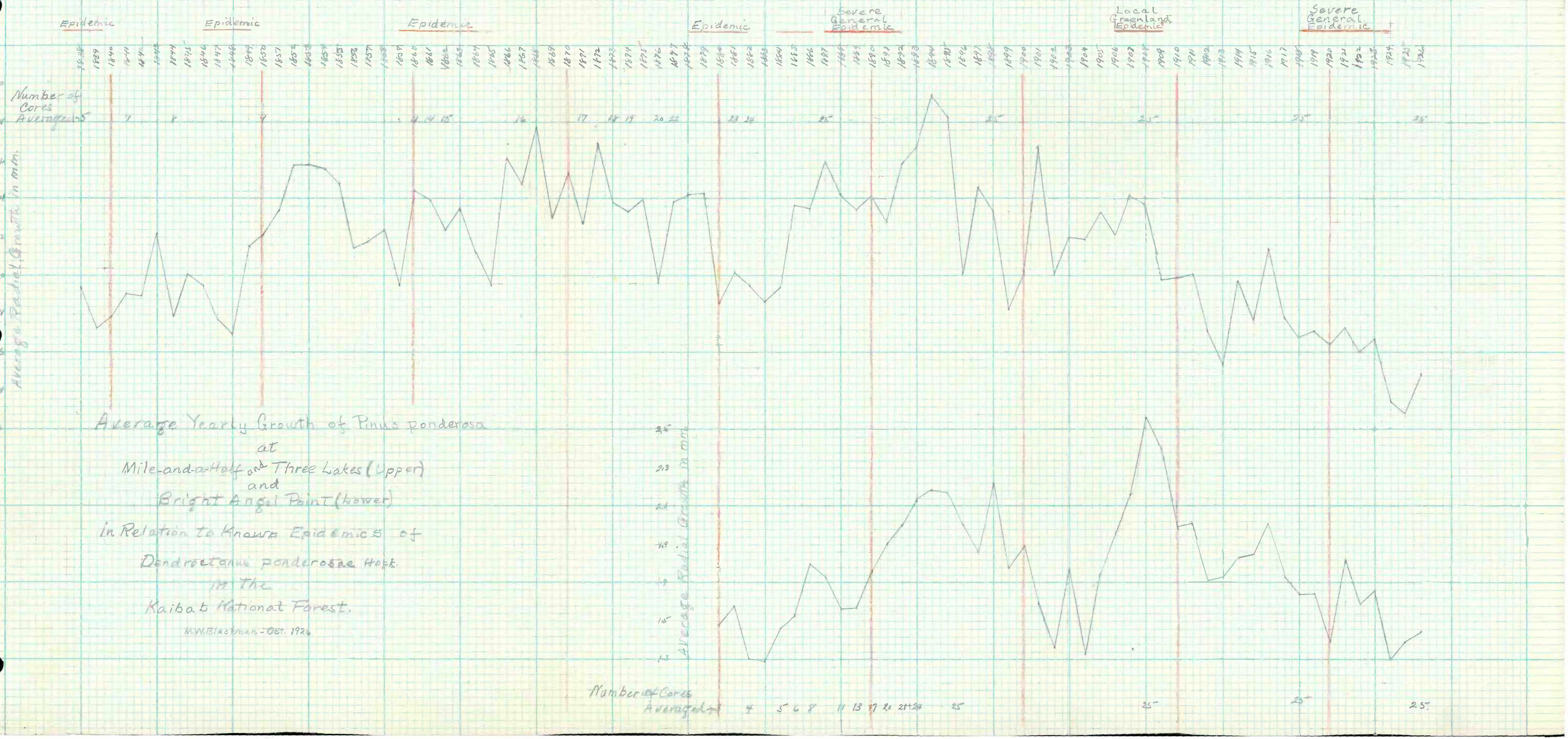
In studying these graphs to see if any relation exists between growth and epidemics two facts are strongly apparent. First, all of the epidemics seem to have started several years following a period of unusually rapid growth at a time when the growth curve was on the decline. Second, in all cases except one the epidemic seems to have been limited (controlled?) by a still further decline in the rate of growth. If this growth curve be considered to represent the curve of available moisture we might say that a condition favorable to the increase of the Black Hills Beetle is produced by several years of deficient precipitation. But if the deficiency in precipitation is continued in increasing ratio for several years conditions become so unfavorable for the brood that the epidemic is brought under natural control.

The one case in which the control of an epidemic is not correlated with a further decrease in the growth rate is that very severe killing centering in 1890. As has already been said there is considerable evidence that this epidemic is a continuation of one starting in the late 70's (about 1878) and extending with varying violence until 1892. The start of this epidemic seems to have been in accord with the general rule spoken of above. This was followed by a decrease in growth rate (available moisture) and the epidemic groups of killed trees became smaller. Then there was a rapid increase in growth rate

(available moisture?) producing apparently favorable conditions for the brood during a period of about 6 years (1885-1890). This was followed by a very great increase in the rate of growth from 1891 to 1894 when the growth-rate at Mile-and-a-Half was greater than at any time in the last hundred years. Apparently this phenomenal increase in growth-rate (available moisture?) is correlated with the control of this particular epidemic.

If we allow ourselves to speculate we might conclude that the optimum condition for the brood of P. ponderosae is produced by a slight deficiency in precipitation following a more or less strong excess. Such a condition if continued for several years is likely to build up the brood to epidemic proportions. But if there is a still farther decrease in precipitation or a sudden great increase over several years conditions become so unfavorable for the beetle that the epidemic is controlled. A considerable variation either way from the optimum condition results in such unfavorable conditions that the infestation is controlled.

But undoubtedly the time rainfall occurs is as important in its effect upon the beetle or perhaps more so than the total amount of available moisture. Thus a moderate amount of rainfall during the early summer is undoubtedly beneficial to the brood while still in the old host. Moderate rainfall just preceeding emergence would soften the bark and make emergence less difficult and eliminate much of the danger of the death of the emerging beetle from dry-killing. Continuous rainfall during the time of flight and attack would probably be fatal to many beetles. Frequent light rains accompanied by warm weather at the time when the larvae are in their first and second instars is likely to produce a "souring of the sap" which is fatal to a large percent of the young larvae. This latter is especially noticeable in tree trunks felled and laid flat on the ground, but also apparently occurs in standing trees which have undergone an especially heavy attack.


Epidemic
Epidemic
Epidemic
Epidemic
Severe General Epidemic
Local Greenland Epidemic
Severe General Epidemic
Number of Cores Averaged
Average Radial Growth in mm.
Average Yearly Growth of Pinus ponderosa
at
Mile-and-a-Half and Three Lakes (Upper)
and
Bright Angel Point (Lower)
in Relation to Known Epidemics of
Dendroctonus ponderosae Hopk.
in the
Kaibab National Forest.
M.W. Blackman - Oct. 1926.